AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 49:271–280 (2006)

Resource ID # 6176

Pesticide Safety Behaviors in Latino Farmworker Family Households

Pesticide Safety Behaviors in Latino Farmworker Family Households

Pamela Rao, PhD,[1] Amanda L. Gentry, BA,[1] Sara A. Quandt, PhD,[2] Stephen W. Davis, MA,[1] Beverly M. Snively, PhD,[2] and Thomas A. Arcury, PhD[1]*

Background *Studies to assess pesticide exposure of individuals living in agricultural settings suggest that farmworkers create a "take-home" pathway from the fields to the home that increases exposure risk for non-farmworker household members.*

Methods *A survey was conducted with 142 Latino women in farmworker family households in North Carolina to identify predictors of adherence to pesticide safety behaviors that may affect take-home exposure risk. Behaviors included changing work clothes before entering the house, storing and washing contaminated work clothes separately from family clothing, and showering upon returning home.*

Results *The number of farmworkers in the household was negatively associated with adherence to recommended changing, storing, and showering behaviors. Most workers followed recommended laundry procedures for work clothes.*

Conclusions *Results support existing evidence for a take-home pathway for pesticide residues in homes with several farmworkers. Pesticide safety education needs to reinforce behaviors that reduce take-home exposure in farmworker households.* Am. J. Ind. Med. 49:271–280, 2006. *© 2006 Wiley-Liss, Inc.*

KEY WORDS: pesticide safety; pesticide safety behaviors; take-home pathway; farmworker families; farmworker housing

INTRODUCTION

The health hazard posed by pesticide exposure is a well-established occupational risk of agricultural work [Arcury and Quandt, 1998; Reeves and Schafer, 2004]. Non-farmworkers, including children, living in farmworker households are also at risk for pesticide exposure and the ensuing health problems [Bradman et al., 1997; Fear et al., 1998; Eskenazi et al., 1999; Faustman et al., 2000; Fenske et al., 2000a,b; Quandt et al., 2004a]. While efforts have been made to require occupational pesticide safety education for workers [US-EPA, 1992], much less attention has been paid to educating non-farmworkers living in agricultural settings about their potential exposure and about ways to reduce the risk to themselves and their family members. This article describes the results of a study to assess the pesticide safety-related behaviors of farmworkers living with non-farmworkers and children, and to identify predictors of adherence to recommended practices for limiting and preventing exposure. The results have implications for improving the efficacy of efforts to reduce pesticide exposure for farmworkers and their non-farmworker family members.

Pesticide Exposure, Risk Behavior, and the Take-Home Pathway

People can come into contact with pesticides in ways other than being present while pesticides are being applied.

[1]Department of Family and Community Medicine, Wake Forest University School of Medicine, North Carolina
[2]Department of Public Health Sciences, Wake Forest University School of Medicine, North Carolina

Study location: Wake Forest University School of Medicine.
Contract grant sponsor: National Institute of Environmental Health Sciences; Contract grant number: R01-ES08739.

*Correspondence to: Thomas A. Arcury, Department of Family and Community Medicine, Wake Forest University School of Medicine, Medical Center Blvd., Winston-Salem, NC 27157-1084. E-mail: tarcury@wfubmc.edu

Accepted 27 December 2005
DOI 10.1002/ajim.20277. Published online in Wiley InterScience (www.interscience.wiley.com)

Para-occupational exposure occurs when agricultural chemicals are transferred from the worksite to the home by farmworkers in the course of their daily activities by means of a "take-home pathway" [Curl et al., 2002; McCauley et al., 2003]. Once pesticides have been transferred from work to the home, non-farmworkers are at risk from exposure despite not having been near any applications or treated crops. Children can pick up and ingest residues via hand-to-mouth activities [Fenske et al., 2000a,b, 2002]. Protected from natural degradation by sunlight and rain, residues can accumulate in the home as long as the take-home pathway remains active [Quandt et al., 2004a].

Studies in agricultural areas throughout the US document the transfer points along the take-home pathway and attempt to identify predictors of exposure. In a series of studies in Washington State, researchers found concentrations of residues in house dust in farmworker homes that were higher than those found in the soil around the homes. Those concentrations were also higher than concentrations found in and around non-agricultural homes [Simcox et al., 1995]. Living near an agricultural field was associated with higher levels of residues on children's hands and of concentrations in house dust in these studies [Lu et al., 2000; Fenske et al., 2000a, 2002]. Relationships were found in these studies between high residue levels in house dust and high concentrations of biomarkers in the urine of children of farmworker parents, especially those who apply pesticides [Loewenherz et al., 1997; Curl et al., 2002]. However, other studies conducted in the same region found no relationship of exposure with specific farm working tasks that would seem to be prone to high levels of exposure, such as handling and applying pesticides [Koch et al., 2002; Coronado et al., 2004].

Studies in California detected residues in dust samples taken from farmworker family housing and in children's hand wipes [Bradman et al., 1997] and biomarkers in children [Mills and Zahm, 2001]. Residues in house dust in an Oregon study were associated with residential density in farmworker housing as well as proximity to fields [McCauley et al., 2001; Lambert et al., 2005]. Residues on hands were associated with urinary levels in a study conducted on the Texas-Mexico border [Shalat et al., 2003]. Research in North Carolina supports these findings, with residues of either agricultural or residential pesticides found in 39 of 41 houses tested [Quandt et al., 2004a]. Studies such as these demonstrate that children are in direct and measurable contact with pesticides in their environments [Fenske et al., 2002; Arcury et al., 2005], although it remains difficult to link a specific exposure conclusively to metabolite levels because of the large number of factors involved.

In order to identify points along the take-home pathway where intervention could influence the exposure route, researchers have looked at specific behaviors of farmworkers. Certain behaviors such as wearing work clothes in the house, washing work clothes with family clothes, and delaying showering after work are all thought to increase the risk of exposure of family members. Studies have shown that adherence to recommended safety precautions are often limited [Arcury et al., 1999; Goldman et al., 2004]. Lack of adherence was associated with higher levels of pesticides in house dust in an Oregon study [McCauley et al., 2003]. Adherence was found to be lower among farmworkers who did not directly handle pesticides in the Washington State studies [Thompson et al., 2003], although the pesticide handlers were not found to be much better. Behaviors such as these are important links in the take-home pathway. This article describes reported adherence to recommended safety behaviors of farmworkers living with children under the age of 13 in northwestern North Carolina and southwestern Virginia, delineates factors related to adherence with recommended safety practices, and discusses their implications for improving pesticide safety health education for farmworker families.

REDUCING FARMWORKER FAMILY PESTICIDE EXPOSURE: THE LA FAMILIA PROJECT

Introduction to the Study

The results from the initial component of the La Familia Project, a community-based participatory research project to develop, implement, and evaluate a lay health educator program to reduce pesticide exposure of farmworker families is described. The project used a pretest-posttest design to document the knowledge and practices of women living in farmworker households regarding pesticide safety before and after receiving lessons in pesticide safety from lay health educators or '*promotoras*.' The data analyzed in this article are from the initial survey that was conducted prior to the implementation of the safety training program.

The La Familia Project was conducted in five mountain counties in Northwest North Carolina (Alleghany, Ashe, Avery, Mitchell, Watauga) and three in Southwest Virginia (Smyth, Grayson, Carroll). An array of insecticides, herbicides, and fungicides are used in mountain agriculture [Cope et al., 1998, 1999a,b; Koch et al., 2002; Kissel et al., 2005], which is dominated by the production of Christmas trees, ornamental plants, and burley tobacco, as well as some vegetables (e.g., cabbage, green beans) and fruits (e.g., apples). As is the case in other parts of the Southeast and the nation [Mines et al., 1997; Carroll et al., 2005], the majority of farmworkers in these counties are Latino immigrants and most of the Latino farmworkers are from Mexico [Arcury et al., 2002; Quandt et al., 2002].

Study Sample

To be eligible to participate in the health education component of La Familia, the participant needed to be a woman living in a household with at least one person who was employed in agricultural labor and living with at least one child of her own aged 13 years or younger. The sampling frame included all households located in the eight mountain agriculture counties that met the criteria. However, estimates of the number of Latino households or farmworker households in these counties cannot be determined; migration to the region continues and many immigrants conceal their presence due to their lack of documentation. These problems are common to hard to reach populations and require sampling and recruitment adapted to the particular circumstances of the study [Faugier and Sargeant, 1997; Arcury and Quandt, 1998; Muhib et al., 2001; Thompson and Collins, 2002; Magnani et al., 2005].

To obtain a sample dispersed through the study area, participants in the study were enrolled with the assistance of the lay health educators who were participating in the development and implementation of the pesticide safety program. The lay health educators were carefully selected by the project team based on their involvement in the community, their capacity for leadership, and their locations throughout the study area. They completed a full day training session, during which they were instructed on recruitment procedures and requirements for maintaining participant confidentiality and obtaining informed consent. Each lay health educator invited women in up to 20 families that fit the eligibility criteria to participate in the pesticide safety program. Most participants were already friends or acquaintances of the lay health educators who recruited them. Potential participants were told that they would be asked to complete an initial survey before receiving any training, and to complete a follow-up survey at the end of the project. The promotoras located and invited 163 women to participate and a total of 142 women completed the initial survey for a response rate of 87%. Total participants recruited ranged from 4 to 22 women per lay health educator.

Data Collection

Data for this analysis were collected as part of the initial surveys conducted prior to the delivery of the pesticide safety program. A questionnaire was developed to gather information about the participant and her family including demographics, household composition, farmwork experience, and pesticide safety training. Information relevant to the take-home pathway collected during the interview included whether the worker has ever brought pesticide containers home from work; the location where the worker changes out of his/her work clothes; the location where the worker stores dirty work clothes; how the worker launders dirty work clothes; and how long the worker waits to shower upon arriving at home after work.

The questionnaire was translated into Spanish by native Spanish speakers and reviewed for accuracy by native English speakers who were fluent in Spanish. Before any interviews were conducted, the questionnaire was pretested with individuals who shared characteristics with the target population but lived outside the study area. The results of the pretest were reviewed to ensure that vocabulary was appropriate and that there was no loss of meaning. Discrepancies in interpretation or word usage were discussed by the project team and resolved before any interviews were conducted.

Data were collected by trained bilingual interviewers who were not participants in the pesticide safety program. Informed consent was obtained from each participant prior to data collection. The study protocol was reviewed and approved by the Wake Forest University School of Medicine Institutional Review Board. All information regarding the household and household members was obtained from the participant. Data on pesticide exposure-related behaviors were collected on up to three members of the household who had been engaged in any type of farmwork in the previous 12 months. The participant and her spouse were always included if eligible under this criterion. If there were other farmworkers in the household, data were collected on the worker identified by the participant as the most heavily engaged in farmwork. The participant, her spouse or partner, and the additional or "other" farmworker on whom data were gathered are referred to here as the "surveyed workers" in a given household.

Measures and Analysis

For each surveyed worker, a set of measures was created in order to analyze the work-related behaviors relevant to the take-home pathway, specifically bringing empty pesticide containers home from work, the location where clothes were changed after work, the storage location for contaminated work clothes, laundry procedures, and the length of time before showering or bathing after returning home. These five behaviors are a subset of the eleven specific areas covered by the Worker Protection Standard (WPS), the federally mandated pesticide safety training for fieldworkers [US-EPA, 1992]. They were selected for analysis because they were the most probable direct link between worksite and household, that is, the take-home pathway that can be addressed via pesticide safety awareness training. For each behavior, surveyed workers were assigned a score of "safe" or "unsafe" depending on whether they were reported by participants as following WPS recommendations. Composite scores for each household were assigned based on the cumulative scores of the workers, reflecting the buildup of pesticides and residues as a result of one or more worker in the household failing to adhere to recommendations.

Workers who were reported as never bringing pesticide containers home from the workplace received a "safe" score. Safe handling of contaminated work clothes was defined as changing either before leaving work or outside the house before entering. Safe storage of contaminated work clothes was to either leave them outside or store them indoors in a specific container separate from the family's regular clothing. Safe laundering of work clothes was to wash them separately from the rest of the family's clothing. The WPS training recommends showering immediately after work; therefore, workers who were reported to shower within 15 min of returning home after work received a "safe" score for that behavior.

The scores for each household's surveyed workers were combined into a composite score of "safe" or "unsafe" for each behavior. Households received a positive, that is, "safe" score on a given behavior if all the surveyed workers were reported as behaving according to safety recommendations. A household received an "unsafe" score on a behavior if any farmworker living in it did not follow recommended practices. For example, if only one of three farmworkers in a particular household was reported to have brought a pesticide container from work, the household receives a score of "unsafe" for pesticide container handling. Frequencies and percentages of "safe" scores were calculated by household and by surveyed worker for each pesticide exposure-related behavior.

Bivariate analyses were conducted to identify potential predictors of safe or unsafe behavior. The independent variables were the participant's age and education level, pesticide safety training of either the participant or her partner, and the number of farmworkers living in the house. Each of these predictors was dichotomized for hypothesis and significance testing using Fisher's Exact Test in SPSS version 12.0. Participant's age was dichotomized as $\leq$29 years and $\geq$30 years, and education was categorized as primary (6 years or less in the Mexican school system) and secondary or above. Pesticide safety training status was dichotomized into neither the participant nor her spouse having received training in the past 12 months versus one or both having received training. The number of workers in the household was dichotomized as exactly one worker versus two or more workers. Significance was assigned to the results with a critical value of $P = 0.1$ using Fisher's Exact Test (2-tailed test). Cases with missing values for a given behavior or predictor were excluded from the analysis; frequencies, percents, and significance values are reported only for valid (non-missing) cases.

Based on the results of the main analyses of this project, hypothesis and significance testing was conducted on additional variables to examine the relationship between which adults in the house were farmworkers and the safe behavior scores for the household and for individual workers. Three dichotomous (yes or no) variables were defined: the participant and/or her spouse were the only farmworkers in the house (i.e., no "other" farmworkers were present); both the participant and her spouse were farmworkers; and the participant did farmwork. The goal of these analyses was to assess the influence of resident workers on overall risk behaviors in the household.

RESULTS

Sample Characteristics

The 142 participants in the study were women between the ages of 16–47 years (mean age of 27.1 (SD $\pm$ 6.02) years). Most participants were currently married or living as married (union libre) (90.8%). Nearly all the participants were from Mexico, with four from Guatemala and one from Honduras. Six were American-born non-Latina women married to Latino farmworkers. Each had between one and six children living with her, ranging in age from newborn to 16 years. Educational levels were relatively low, with 45.8% completing less than 6 years (primaria) of formal schooling. Educational levels of the partners were slightly lower overall, with 57.0% attending for less than 6 years.

Nearly half the participants (68; 47.9%) had engaged in some form of farmwork during the previous 12 months, as had a majority of the 129 partners (115; 89.1%). In two-third of the households, the participant or her spouse were the only farmworkers (66.9%), 19.0% had one additional worker, and 14.1% had from two to six additional workers. Half the households had no more than one farmworker living in them, while the remaining half had from two to eight workers. Pesticide safety training was relatively uncommon among the participants and among the workers with whom they lived. Three out of four households (109; 76.8%) had at least one untrained worker living in them including 87 households (61.3%) with no trained workers. All surveyed workers had received training in 33 households (23.2%). Nine of the participant farmworkers had received training (13.2%), while one-third of the spouse farmworkers (n = 42; 36.5%) and "other" farmworkers (n = 17; 36.2%) had received training in the past 12 months.

The families lived in a variety of dispersed housing types; none of the families participating in this study resided in traditional farmworker camps. Over half the households (58.5%) were located in mobile homes, and over a quarter (27.5%) lived in single-family dwellings. The remaining 14% lived in apartment complexes of various sizes. Three-fourths of the dwellings had one bathroom and the remaining quarter had two bathrooms.

The final sample included 230 farmworkers living in the 142 households. Of the 230 farmworkers, 68 were study participants, 115 were spouses, and 47 were other individuals living with the participant. In five households, neither the participant nor her spouse was currently employed in farmwork. In these cases, data were recorded for the "other" worker.

Frequency of Pesticide Exposure-Related Behaviors

Two of the 142 participants (1.4%) reported that any workers in their household brought pesticide containers from the worksite (Table I). In two of five households (39.4%), all surveyed workers changed clothes safely after work, that is, either while still at work or outside the house before entering. Farmworker spouses were the most likely to change safely (42.1%) and "other" farmworkers were the least likely (17.1%). Of the farmworker women, 30.9% changed their work clothes safely.

Over 90% of households and workers in the study reported storing contaminated work clothes in the recommended manner, that is, separately from the family's regular laundry. In 94.4% of households, all surveyed workers stored their work clothes properly. This includes 91% of the farmworker participants, 94.6% of the spouses, and 92.5% of "other" workers.

Most workers reported laundering work clothes separately from the rest of the family's daily clothing. In all but two households (98.6%), all surveyed workers separated their laundry. All but one participant (98.5%), all but four spouses, and all "other" workers reported separating work clothes from other laundry.

A sizeable number of workers reported not always showering within 15 min after returning home from work. Over a quarter of the participants reported that at least one worker in the household delayed showering ("safe" = 73.2%). Spouses were slightly more likely to shower soon after work (75.4%), while participants (66.2%) and "other" workers (62.5%) were less likely to shower within 15 min.

Predictors of Pesticide Exposure-Related Behaviors

Having more than one farmworker in the house was negatively associated with several pesticide exposure-related behaviors at both individual and household levels (Table II). Households with two or more farmworkers were significantly less likely to report that all workers changed clothes before entering the house ($P < 0.001$) and that all workers showered within 15 min after returning home ($P < 0.001$). Spouses in households with two or more workers were significantly less likely to change clothes safely ($P < 0.001$), as were participants ($P < 0.05$), than in households with a single farmworker. Participants were significantly more likely to delay showering after work ($P < 0.001$) than were spouses ($P < 0.05$) in multiple farmworker households. Storing clothes separately was also negatively associated with number of workers, though not as strongly, both for households ($P < 0.10$) and for spouses ($P < 0.05$). Households in which the age of the participant was 30 years or more were more likely to report that surveyed workers showered within 15 min ($P < 0.05$).

Pesticide safety training of the participant or her spouse was positively associated with the household's and the spouse's score for storing clothes separately ($P < 0.10$). None of the variables varied with participant's educational attainment.

To summarize, of the four potential predictors tested, the number of farmworkers living in the household had the strongest and most consistent effect on pesticide exposure-related behaviors. The greatest risk that work clothes would be changed unsafely was found in households with two or more farmworkers. There was a trend towards storing work clothes more safely in households where the participant or her spouse had received training, and in households with no more than one farmworker. Finally, workers were more likely to shower soon after work in households with participants aged 30 years or more, but less likely in houses with two or more workers.

Since the most significant relationships between three of the four pesticide exposure-related behaviors (changing, storing, showering) were with the number of workers living

TABLE I. Frequencies of Pesticide Safety Behaviors Reported as "Safe" for All Surveyed Workers in Household; for Participants, Spouses, "Other" Workers

	All workers[a] (n = 142)	Participant[b] (n = 68)	Spouse[b] (n = 115)	"Other" worker[b] (n = 47)
Behavior	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)
Leaving pesticide containers at work	140 (98.6)	68 (100.0)	113 (98.3)	47 (100.0)
Changing contaminated work clothes outside the house	56 (39.4)	21 (30.9)	48 (42.1)	7 (17.1)
Storing contaminated work clothes outside or in a separate container	134 (94.4)	61 (91.0)	105 (94.6)	37 (92.5)
Laundering contaminated work clothes separately from family's clothing	140 (98.6)	67 (98.5)	111 (98.2)	40 (100.0)
Showering within 15 min of returning home after work	104 (73.2)	45 (66.2)	86 (75.4)	25 (62.5)

[a]All surveyed workers in household adhere to recommended safety practices.
[b]Individual adheres to recommended safety practice.

TABLE II. Behaviors Reported as "Safe" for Surveyed Farmworkers in Household by Participant's Age and Education, Pesticide Safety Training, and Number of Farmworkers*

	Participant age		Participant education		Participant and/or spouse received safety training		Number of farmworkers in household	
	≤29 years (n = 91)	≥30 years (n = 51)	≤Primary (n = 65)	≥Secondary (n = 77)	Neither (n = 97)	One or both (n = 45)	1 worker (n = 71)	2+ workers (n = 71)
	Count (%)	Count (%)	Count (%)	Count (%)	Count (%)	Count (%)	Count (%)	Count (%)
Change clothes at work or outside house								
All workers	33 (36.3)	23 (45.1)	23 (35.4)	33 (42.9)	39 (40.2)	17 (37.8)	42 (60.0)	14 (19.4)‡
Participant	10 (23.8)	11 (42.3)	5 (19.2)	16 (38.1)	17 (34.7)	4 (21.1)	9 (56.3)	12 (23.1)***
Spouse	NA	NA	NA	NA	29 (42.0)	19 (42.2)	29 (61.7)	19 (28.4)‡
Store clothes separately								
All workers	86 (94.5)	48 (94.1)	63 (96.9)	71 (92.2)	89 (91.8)	45 (100.0)**	70 (98.6)	64 (90.3)**
Participant	39 (92.9)	22 (88.0)	24 (96.0)	37 (88.1)	42 (87.5)	19 (100.0)	15 (93.8)	46 (90.2)
Spouse	NA	NA	NA	NA	61 (91.0)	44 (100.0)**	46 (100.0)	59 (90.9)**
Wash clothes separately								
All workers	91 (100.0)	49 (96.1)	64 (98.5)	76 (98.7)	95 (97.9)	45 (100.0)	69 (98.6)	71 (98.6)
Participant	42 (100.0)	25 (96.2)	26 (100.0)	41 (97.6)	48 (98.0)	19 (100.0)	16 (100.0)	51 (98.1)
Spouse	NA	NA	NA	NA	66 (97.1)	45 (100.0)	45 (97.8)	66 (98.5)
Shower within 15 min after work								
All workers	61 (67.0)	43 (84.3)***	51 (78.5)	53 (68.8)	70 (72.2)	34 (75.6)	64 (91.4)	40 (55.6)‡
Participant	25 (59.5)	20 (76.9)	18 (69.2)	27 (64.3)	33 (67.3)	12 (63.2)	16 (100.0)	29 (55.8)‡
Spouse	NA	NA	NA	NA	49 (71.0)	37 (85.2)	42 (89.4)	44 (65.7)***

*Sample sizes (n) are for households; counts and percentages are calculated separately among all workers, participants, and spouses.
**$P \leq 0.10$.
***$P \leq 0.05$.
‡$P \leq 0.001$.

in the household, hypotheses were tested on the participant's and her spouse's current farmworker status and the presence of "other" workers. Households in which there were "other" farmworkers besides the participant or her spouse were significantly less likely to report that all workers changed their clothes outside the house (21.3% vs. 48.4%; $P < 0.05$) and that all workers showered within 15 min of returning home (55.3% vs. 82.1%; $P < 0.001$). Put another way, households in which the only farmworkers were the participant or her spouse were significantly safer on these two behaviors than those with additional workers were. Households where both spouses were engaged in farmwork (regardless of whether there were also "other" workers) were less likely to report changing safely (18.8% vs. 50.0%; $P < 0.001$), but more likely to report showering safely (56.3% vs. 11.7%; $P < 0.005$). Finally, the 68 households in which the participants were farmworkers (as opposed to those in which the participant did not do any farmwork) were significantly more likely to report improper clothes changing behavior (27.9% vs. 50.0%; $P < 0.010$) and delayed showering after work (66.2% vs. 79.7%; $P < 0.10$).

DISCUSSION

The findings of this study support the previously reported model of a take-home pesticide exposure pathway between the agricultural workplace and the home. When combined with other studies of exposure predictors, they reinforce existing knowledge on the means by which transfer most likely takes place. First, studies of farmworker and non-farmworker families with children in agricultural regions have measured higher levels of pesticides and residues in houses with farmworkers [Simcox et al., 1995; Bradman et al., 1997; Fenske et al., 2000a; Lu et al., 2000]. Second, living with farmworker parents has been associated with increased urinary biomarker levels in children [Fenske et al., 2000a; Lu et al., 2000; Mills and Zahm, 2001; Coronado et al., 2004; Lambert et al., 2005]. Third, a larger number of workers in the household have been associated with higher urinary metabolite concentrations in children [Arcury et al., 2005]. Larger households, especially those with several farmworkers, have been found to have elevated levels of pesticide residues [McCauley et al., 2001], and to be more likely to exhibit unsafe behaviors [Goldman et al., 2004]. The findings reported here provide additional evidence that the number of farmworkers is an important factor in the take-home exposure pathway.

The results of the exploratory analyses suggest that the presence of workers besides the male householder makes the greatest contribution to the reported failure to change and shower safely. As the number of workers who must share limited living space and bathing facilities increases, more time will be required for all of them to change out of their work clothes and shower after returning home from work. Delaying changing clothes after work has been associated with higher residue levels in household dust [McCauley et al., 2001, 2003], as would be predicted by the take-home pathway model. Any pesticides or residues that may be on their clothing or boots will be introduced into the living area unless workers are able to remain outside the house until they have access to bathing facilities [Early et al., 2006].

The findings that all workers reported washing their work clothes separately from the family's regular clothes and that the only behavior that varied with the pesticide safety training status of the participant or her spouse was storing clothes separately is supported by the findings of another study in which training was found to have an influence on laundry handling behaviors [Acosta et al., 2005]. The near-universality of washing clothes separately may be an outcome of the belief, documented in another part of this study, that workers and their families assume that pesticide toxicity is linked to its odor [Rao et al., 2006]. The odor may be a reminder at laundry time that dangerous pesticides on the clothes could transfer to other clothing during the wash process. Storing contaminated work clothes separately from other laundry was almost as common, and safety training showed a trend towards encouraging this behavior.

The generally poor quality of farmworker housing makes compliance with safe behaviors difficult and limits the effectiveness of measures to mitigate exposure [Holden, 2001; Early et al., 2006]. Crowding is common in farmworker households, which limits space for storing contaminated clothing. There may be no place outside the dwelling that is appropriate for changing out of work clothes for workers who cannot change before leaving work. This may particularly affect the behavior of women who may be reluctant to change clothes without privacy due to norms of modesty. Many dwellings only have one bathroom, so that in any household with more than one worker, someone must delay showering after work if there are no alternative facilities. Farmworker housing is often old, in need of repair, and difficult to clean. Drift from nearby pesticide applications can enter the house through broken windows, torn screens, and other damage to the exterior of the house. Housing that is difficult to clean is more likely to harbor residues [Quandt et al., 2004b]. On the other hand, lack of laundry machines could conceivably encourage separation of laundry if each worker washes his/her own work clothes at a public facility. Although that last conjecture has not been tested, it would be consistent with the findings of this study.

Since the number of workers in the household was the most significant predictor of risky behaviors, and has been associated with high levels of residues and biomarkers in other studies [McCauley et al., 2001, 2003], it is reasonable to conclude that the two outcomes are related. These results have important implications for pesticide safety training and have implications for policy regarding farmworker housing standards. The government-mandated pesticide safety training for field workers [US-EPA, 1992] primarily emphasizes workplace safety measures that do not necessarily influence the take-home pathway [Arcury et al., 1999; Goldman et al., 2004]. This study offers additional evidence of the disconnect between workplace training and safety behaviors at home. Many women who live with farmworkers do not receive this training regardless of whether they are farmworkers themselves. Yet, they are by and large responsible for safeguarding the health of others in the household [Chavira-Prado, 1992]. Alternative means for disseminating safety information that do not depend on the workplace need to be developed.

Farmworker women (especially mothers) may face special challenges to promoting recommended behaviors when they share their home with several farmworkers, particularly unrelated males. Traditional male-dominated Mexican culture restricts women's capacity to control the behavior of the men in the household [Hondagneu-Sotelo, 1992; Harris and Firestone, 1998]. This limits their ability to insist on compliance with safe behaviors, especially by unrelated farmworkers. However, in order to even attempt to reduce pesticide exposure in the home, women in farmworker households must be aware of the potential problem including its sources and solutions. As documented in related research with a similar population [Rao et al., 2006], farmworker women were often not aware of the problem and learned what little they know about pesticide safety from their spouses. They believed that pesticides were an issue only for those who work directly with pesticides, and that those who do not work in fields are at limited, if any, risk of exposure. Since children in this population do not work in the fields, exposure is not considered a problem. Home exposure could be avoided by handling the work clothes separately from other laundry. This was not difficult to remember to do since it was covered generally with dirt and smelled of pesticides.

The generalizability of this study is restricted because data collection was limited to the mountains of North Carolina and Virginia, which has a different crop mix from the other areas of the country where pesticide exposure of farmworkers has been recorded. The results might have been different if data had been collected on all workers living in the household in addition to the participant and her spouse rather than on only one "other" worker. Also, all behaviors were reported by one individual in the household on behalf of all workers, which increases the likelihood of error in either direction, positive or negative. Certain questions such as whether the worker had received safety training, must be interpreted broadly since it is not possible to retrospectively determine the content or value of the training received. The use of a critical level of $P < 0.10$ to determine statistical significance may overstate the importance of some relationships. Finally, no physical pesticide data were collected from the homes. Nevertheless, the findings clearly overlap with those of studies conducted in different parts of the country, and do support the concept of a workplace-to-home transfer pathway for pesticides and residues.

CONCLUSION

The findings of this research suggest two promising avenues for addressing pesticide exposure for farmworker families. First, housing for farmworker families that provides sufficient bathroom and laundry facilities for the number of occupants would increase the chances that workers will engage in safe showering and laundry handling behaviors. Also, housing that is kept in good repair can be more easily kept free of pesticide drift and cleaned of take-home residues. Given the scarcity of affordable, quality housing available to farmworker families, this issue needs to be addressed at the policy level. Second, it is inaccurate to assume that pesticide safety information received by workers under the WPS will be disseminated to their family members. However, the evidence that exposure is taking place in the home of farmworker families is strong. Separate and independent pesticide safety training programs that emphasize the specific situation of non-farmworkers at risk for take-home exposure needs to be developed. Better housing and accurate, practical safety information are the critical resources that farmworker families need to protect themselves from preventable pesticide exposure.

REFERENCES

Acosta MSV, Chapman P, Bigelow PL, Kennedy C, Buchan RM. 2005. Measuring success in a pesticide risk reduction program among migrant farmworkers in Colorado. Am J Ind Med 47:237–245.

Arcury TA, Quandt SA. 1998. Chronic agricultural chemical exposure among migrant and seasonal farmworkers. Soc Nat Resour 11:829–843.

Arcury TA, Quandt SA, Austin CK, Preisser J, Cabrera LF. 1999. Implementation of US-EPA's Worker Protection Standard training for agricultural laborers: An evaluation using North Carolina data. Public Health Rep 114:459–468.

Arcury TA, Quandt SA, Russell GB. 2002. Pesticide safety among farmworkers: Perceived risk and perceived control as factors reflecting environmental justice. Environ Health Perspect 110:233–239.

Arcury TA, Quandt SA, Rao P, Doran AM, Snively BM, Barr DB, Hoppin JA, Davis SW. 2005. Organophosphate pesticide exposure in farmworker family members in western North Carolina and Virginia: Case comparisons. Hum Organ 64:40–51.

Bradman MA, Harnly ME, Draper W, Seidel S, Teran S, Wakeham D, Neutra R. 1997. Pesticide exposures to children from California's Central Valley: Results of a pilot study. J Expo Anal Environ Epidemiol 7:217–234.

Carroll DJ, Samardick R, Bernard S, Gabbard S, Hernandez T. 2005. Findings from the National Agricultural Workers Survey (NAWS) 2001–2002: A demographic and employment profile of United States farm workers. Report No. 9. Washington, DC: US Department of Labor, Office of the Assistant Secretary for Policy.

Chavira-Prado A. 1992. Work, health, and the family: Gender structure and women's status in an undocumented migrant population. Hum Organ 51:53–64.

Cope WG, Avery RC, Storm JF, Luginbuhl R. 1998. Pesticides & human health: Tobacco. Raleigh, NC: North Carolina Cooperative Extension.

Cope WG, Avery RC, Storm JF, Luginbuhl R. 1999a. Pesticides & human health: Apples. Raleigh, NC: North Carolina Cooperative Extension.

Cope WG, Avery RC, Storm JF, Luginbuhl R. 1999b. Pesticides & human health: Christmas trees. Raleigh, NC: North Carolina Cooperative Extension.

Coronado GD, Thompson B, Strong L, Griffith WC, Islas I. 2004. Agricultural task and exposure to organophosphate pesticides among farmworkers. Environ Health Perspect 112:142–147.

Curl CL, Fenske RA, Kissel JC, Shirai JH, Moate TF, Griffith W, Coronado G, Thompson B. 2002. Evaluation of take-home organophosphorus pesticide exposure among agricultural workers and their children. Environ Health Perspect 110:A787–A792.

Early J, Davis SW, Quandt SA, Rao P, Snively BM, Arcury TA. 2006. Housing characteristics of farmworker families in North Carolina. J Immigrant Minor Health (in press).

Eskenazi B, Bradman A, Castorina R. 1999. Exposures of children to organophosphate pesticides and their potential adverse health effects. Environ Health Perspect 107(Suppl 3):409–419.

Faugier J, Sargeant M. 1997. Sampling hard to reach populations. J Adv Nurs 26:790–797.

Faustman EM, Silbernagel SM, Fenske RA, Burbacher TM, Ponce RA. 2000. Mechanisms underlying children's susceptibility to environmental toxicants. Environ Health Perspect 108:13–21.

Fear NT, Roman E, Reeves G, Pannett B. 1998. Childhood cancer and paternal employment in agriculture: The role of pesticides. Br J Cancer 77:825–829.

Fenske RA, Kissel JC, Lu CS, Kalman DA, Simcox NJ, Allen EH, Keifer MC. 2000a. Biologically based pesticide dose estimates for children in an agricultural community. Environ Health Perspect 108: 515–520.

Fenske RA, Lu CS, Simcox NJ, Loewenherz C, Touchstone J, Moate TF, Allen EH, Kissel JC. 2000b. Strategies for assessing children's organophosphorus pesticide exposures in agricultural communities. J Expo Anal Environ Epidemiol 10:662–671.

Fenske RA, Lu C, Barr DB, Needham L. 2002. Children's exposure to chlorpyrifos and parathion in an agricultural community in central Washington State. Environ Health Perspect 110:549–553.

Goldman L, Eskenazi B, Bradman A, Jewell NP. 2004. Risk behaviors for pesticide exposure among pregnant women living in farmworker households in Salinas, California. Am J Ind Med 45:491–499.

Harris RJ, Firestone JM. 1998. Changes in predictors of gender role ideologies among women: A multivariate analysis. Sex Roles 38:239–252.

Holden C. 2001. Housing. Buda, TX: National Center for Farmworker Health, Inc.

Hondagneu-Sotelo P. 1992. Overcoming patriarchal constraints: The reconstruction of gender relations among Mexican immigrant women and men. Gender Soc 6:393–415.

Kissel JC, Curl CL, Kedan G, Lu CS, Griffith W, Barr DB, Needham LL, Fenske RA. 2005. Comparison of organophosphorus pesticide metabolite levels in single and multiple daily urine samples collected from preschool children in Washington State. J Expo Anal Environ Epidemiol 15:164–171.

Koch D, Lu CS, Fisker-Andersen J, Jolley L, Fenske RA. 2002. Temporal association of children's pesticide exposure and agricultural spraying: Report of a longitudinal biological monitoring study. Environ Health Perspect 110:829–833.

Lambert WE, Lasarev M, Muniz J, Scherer J, Rothlein J, Santana J, McCauley L. 2005. Variation in organophosphate pesticide metabolites in urine of children living in agricultural communities. Environ Health Perspect 113:504–508.

Loewenherz C, Fenske RA, Simcox NJ, Bellamy G, Kalman D. 1997. Biological monitoring of organophosphorus pesticide exposure among children of agricultural workers in central Washington State. Environ Health Perspect 105:1344–1353.

Lu CS, Fenske RA, Simcox NJ, Kalman D. 2000. Pesticide exposure of children in an agricultural community: Evidence of household proximity to farmland and take home exposure pathways. Environ Res 84:290–302.

Magnani R, Sabin K, Saidel T, Heckathorn D. 2005. Review of sampling hard-to-reach and hidden populations for HIV surveillance. AIDS 19(Suppl 2):S67–S72.

McCauley LA, Lasarev MR, Higgins G, Rothman N, Muniz J, Ebbert C, Phillips J. 2001. Work characteristics and pesticide exposures among migrant agricultural families: A community-based research approach. Environ Health Perspect 109:533–538.

McCauley LA, Michaels S, Rothlein J, Muniz J, Lasarev MR, Ebbert C. 2003. Pesticide exposure and self reported home hygiene. AAOHNJ 51: 113–119.

Mills PK, Zahm S. 2001. Organophosphate pesticide residues in urine of farmworkers and their children in Fresno County, CA. Am J Ind Med 40: 571–577.

Mines R, Gabbard SM, Steirman A. 1997. A profile of US farm workers: Demographics, household composition, income and use of services. Based on data from the National Agricultural Workers Survey (NAWS). Washington, DC: US Department of Labor, Office of Program Economics Research.

Muhib FB, Lin LS, Stueve A, Miller RL, Ford WL, Johnson WD, Smith PJ, Community Intervention Trial for Youth Team Study. 2001. A venue-based method for sampling hard-to-reach populations. Public Health Rep 116(Suppl 1):216–222.

Quandt SA, Preisser J, Arcury TA. 2002. Mobility patterns of migrant farmworkers in North Carolina: Implications for occupational health research and policy. Hum Organ 61:21–29.

Quandt SA, Arcury TA, Rao P, Snively BM, Camann DE, Doran AM, Yau AY, Hoppin JA, Jackson DS. 2004a. Agricultural and residential pesticides in wipe samples from farmworker family residences in North Carolina and Virginia. Environ Health Perspect 112:382–387.

Quandt SA, Doran AM, Rao P, Hoppin JA, Snively BM, Arcury TA. 2004b. Reporting pesticide assessment results to farmworker families: Development, implementation and evaluation of a risk communication strategy. Environ Health Perspect 112(5):636–642.

Rao P, Quandt SA, Doran AM, Snively BM, Arcury TA. 2006. Pesticides in homes of farmworkers: Latino mothers' perceptions of risk to their children's health. Health Educ Behav (in press).

Reeves M, Schafer KS. 2004. Greater risks, fewer rights: U.S. farmworkers and pesticides. Int J Occup Environ Health 9:30–39.

Shalat SL, Donneley KC, Freeman NCG, Calvin JA, Ramesh S, Jimenez M, Black K, Coutinho C, Needham LL, Barr DB, Ramirez J. 2003. Nondietary ingestion of pesticides by children in an agricultural community on the US/Mexico border: Preliminary results. J Expo Anal Environ Epidemiol 13:42–50.

Simcox NJ, Fenske RA, Wolz SA, Lee IC, Kalman DA. 1995. Pesticides in household dust and soil: Exposure pathways for children of agricultural families. Environ Health Perspect 103:1126–1134.

Thompson B, Coronado GD, Grossman JE, Puschel K, Solomon CC, Curl CL, Shirai JH, Kissel JC, Fenske RA. 2003. Pesticide take-home pathways among children of agricultural workers: Study design, methods and baseline findings. J Occup Environ Med 45: 42–53.

Thompson SK, Collins LM. 2002. Adaptive sampling in research on risk-related behaviors. Drug Alcohol Depend 68(Suppl 1):S57–S67.

US-EPA. 1992. Worker protection standard: Pesticide safety training for workers. 40 CFR Part 170.130. Washington, DC: US-GPO.